Low Impact Development
Green Infrastructure and so much more...

Leslie Yetka
Education Manager – Minnehaha Creek Watershed District
Topics to cover...

The *Why*
- Impacts of stormwater runoff
  - Volume, rate, quality

The *What*:
- Regulations
  - Clean Water Act and MS4’s
  - TMDL’s

The *How*:
- Traditional Treatment
- Conservation/Smart Design
- Low Impact Development (LID)
- Green Infrastructure (GI)
- Benefits
- Maintenance
Topics to cover...

The *Why*

- Impacts of stormwater runoff
  - Volume, rate, quality
Impaired Lakes and Rivers

“303(d) list”
3,638 impairments on 400+ rivers and 1,696 lakes

- Heavy Metals: 49%
- Excess Nutrients: 15%
- Sediment: 10%
- Bacteria: 11%
- Biologic: 10%
- Other: 5%
- Other: 5%
What is a Watershed?

An area of land that drains into a body of water such as a lake, river, stream, or wetland.
What is Stormwater Runoff?

- Stormwater runoff is water flowing over land, plus anything carried along with it.

- Stormwater runoff comes from all forms of precipitation:
  - Rain
  - Snow
  - Sleet
  - Melting piles of ice/snow
Urban runoff...

1. Quantity of water (volume)
2. What’s in it (quality)
3. How fast it’s moving (rate of flow)
Natural Area

- 0-10%
- 50%

Some Development

- 25%
- 35%

Mostly Developed

- 50%
- 0-20%
Development Shortcomings

- Inadequately treated **runoff**
- Excessive runoff **volume**
- Lost **shoreline habitat**, aquatic and terrestrial
- Insensitive to **sensitive areas**
### Rainfall – 24 hrs

<table>
<thead>
<tr>
<th>Event frequency</th>
<th>Minnesota range (inches)</th>
<th>Twin Cities approximate average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-year</td>
<td>1.8 - 2.6</td>
<td>2.4</td>
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<tr>
<td>2-year</td>
<td>2.1 - 2.9</td>
<td>2.75</td>
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<tr>
<td>5-year</td>
<td>2.8 - 3.7</td>
<td>3.65</td>
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<tr>
<td><strong>10-year</strong></td>
<td><strong>3.3 - 4.4</strong></td>
<td><strong>4.2</strong></td>
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<tr>
<td>25-year</td>
<td>3.9 - 5.0</td>
<td>4.8</td>
</tr>
<tr>
<td>50-year</td>
<td>4.4 - 5.6</td>
<td>5.3</td>
</tr>
<tr>
<td>100-year</td>
<td>4.8 - 6.2</td>
<td>5.95</td>
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</tbody>
</table>
## Climate modeling: current and future (24 hrs)

<table>
<thead>
<tr>
<th>Return period (years)</th>
<th>Recent climate</th>
<th>mid-21st cent. Optimistic</th>
<th>mid-21st cent. Moderate</th>
<th>mid-21st cent. Pessimistic</th>
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</thead>
<tbody>
<tr>
<td>2.5</td>
<td>2.5</td>
<td>2.84</td>
<td>3.3</td>
<td>6.86</td>
</tr>
<tr>
<td>5</td>
<td>3.17</td>
<td>3.47</td>
<td>4.11</td>
<td>8.4</td>
</tr>
<tr>
<td>7.5</td>
<td>3.57</td>
<td>3.88</td>
<td>4.66</td>
<td>9.39</td>
</tr>
<tr>
<td>10</td>
<td><strong>3.86</strong></td>
<td><strong>4.19</strong></td>
<td><strong>6.56</strong></td>
<td><strong>10.13</strong></td>
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<td>25</td>
<td>4.84</td>
<td>5.28</td>
<td>6.74</td>
<td>12.75</td>
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<td>50</td>
<td>5.67</td>
<td>6.22</td>
<td>8.31</td>
<td>15.03</td>
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<tr>
<td>75</td>
<td>6.2</td>
<td>6.82</td>
<td>9.39</td>
<td>16.5</td>
</tr>
<tr>
<td>100</td>
<td>6.59</td>
<td>7.27</td>
<td>10.23</td>
<td>17.59</td>
</tr>
</tbody>
</table>

Note: Values indicate expected changes compared to recent climate conditions.
## Hydrologic Soil Groups

<table>
<thead>
<tr>
<th>Hydrologic soil group</th>
<th>Infiltration rate (inches/hour)</th>
<th>Soil textures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.63(^a)</td>
<td>gravel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sandy gravel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>silty gravels</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
<td>sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>loamy sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sandy loam</td>
</tr>
<tr>
<td>B</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.3</td>
<td>loam, silt loam</td>
</tr>
<tr>
<td>C</td>
<td>0.2</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>D</td>
<td>0.06</td>
<td>clay loam; silty clay loam;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sandy clay; silty clay;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>clay</td>
</tr>
</tbody>
</table>
Flow Rate

Developed Condition: Higher Peak, More Volume, & Earlier Peak Time

Natural Condition

Hydrograph Pre/ Post Development

Time
Rain that falls soaks into the soil by infiltrating...
...where it flows underground into our lakes, streams and wetlands
Impervious Surfaces

Rain falls on our roadways, parking lots & roofs, where it CAN’T soak into the ground...
What is in runoff?

Non-Point Source Pollution (NPS)

Pollution from a diffuse source versus a ‘point discharge’
Nutrients

Phosphorus (P)
Nitrogen (N)

*1 lb of P supports 500 lbs of algae
Sediment
Chemicals

Oil
Gas
Pesticides
Other

Garbage

Pathogens (bacteria)

Thermal stress (warm water)
850 billion gallons of untreated sewage spilled in 770 cities every year
Pollutant Spectrum in Runoff

- Soluble / Dissolved (~45%)
  - Colloids
- Organic / Float
- Gross Solids
- Clay
- Silt
- Sand

Varies by:
- Pollutant
- Location in management system

Andy Erickson, SAFL
Topics to cover...

The *What*:
- Regulations
  - Clean Water Act and MS4’s
  - TMDL’s
Regulatory History of Stormwater Management

- 1972 Clean Water Act
- 1987 NPDES Permit (construction, industrial, municipal)
  - Phase I – large cities (Mpls, St. Paul)
  - Phase II – medium and small
  - Point-source discharges and outfalls
- Stormwater Pollution Prevention Plans (SWPPP’s)
- New MS4 permit required
What is a TMDL?

A **Total Maximum Daily Load**

a Clean Water Goal

- Required by federal Clean Water Act – Delegated to Mn Pollution Control Agency (MPCA)
- Scientific study conducted on impaired waters to determine how much a pollutant load needs to be reduced
- Purpose: “... to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.”

~60 µg/l TP
TMDL Process

- Assess water quality
- Add to Impaired Waters List (303d list)
- Conduct TMDL study:
  - Determine loading capacity
  - Identify and quantify sources
  - Determine reductions needed
  - Assign load allocations (LA)

Design Strategy
Adaptive Management
Monitor
Evaluate
Assess Progress
Implement
TMDL Process

- Develop implementation plan
- Track progress

- Design Strategy
- Implement
- Monitor
- Evaluate
- Adaptive Management
- Assess Progress
## TMDL Implementation Plan
### Wassermann Lake

<table>
<thead>
<tr>
<th>Source</th>
<th>Existing Load (lbs/yr)</th>
<th>Target Load (lbs/yr)</th>
<th>Load Reduction (lbs/yr)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Load</td>
<td>505</td>
<td>63</td>
<td>442</td>
<td>88%</td>
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<tr>
<td>Atmospheric Deposition</td>
<td>44</td>
<td>44</td>
<td>0</td>
<td>0%</td>
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<tr>
<td>Non-reg. Stormwater</td>
<td>55</td>
<td>51</td>
<td>4</td>
<td>7%</td>
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<tr>
<td>Laketown Twp</td>
<td>147</td>
<td>124</td>
<td>23</td>
<td>16%</td>
</tr>
<tr>
<td>Carver County</td>
<td>2.5</td>
<td>1.3</td>
<td>1.2</td>
<td>48%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>753</strong></td>
<td><strong>283</strong></td>
<td><strong>470</strong></td>
<td><strong>62%</strong></td>
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<tr>
<td>Implementation Activity</td>
<td>P Load Reduction</td>
<td>Cost</td>
<td>Timeline</td>
<td>Partners</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------------------</td>
<td>-----------------</td>
<td>--------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Install Stormwater BMPs</td>
<td>Low</td>
<td>$100,000-220,000</td>
<td>2010-2020</td>
<td>Victoria/MnDOT</td>
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<tr>
<td>Education Program</td>
<td>Low</td>
<td>--</td>
<td>2010-2030</td>
<td>MCWD, Carver County, Victoria, Laketown Twp</td>
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<tr>
<td>Marsh Lake/WL Wetland Restoration</td>
<td>High</td>
<td>$1,408,800</td>
<td>2010-2012</td>
<td>MCWD</td>
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<tr>
<td>Marsh Lake MP</td>
<td>Low</td>
<td>$20,000-40,000</td>
<td>2010-2012</td>
<td>MCWD, MPCA</td>
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<tr>
<td>Wetland Restoration</td>
<td>High</td>
<td>$400,000-600,000</td>
<td>2010-2030</td>
<td>Carver County, MCWD, Laketown Twp, Victoria</td>
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<tr>
<td>Internal Load Project</td>
<td>High</td>
<td>$231,600</td>
<td>2013-2018</td>
<td>MCWD</td>
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<tr>
<td>Shoreline Restoration</td>
<td>Low</td>
<td>$20,000-30,000</td>
<td>2010-2030</td>
<td>MCWD, Victoria, Laketown Twp</td>
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<tr>
<td>Municipal Ordinances</td>
<td>Med</td>
<td>$5000-15,000</td>
<td>2010</td>
<td>Victoria, Laketown Twp</td>
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</table>
Topics to cover...

The *How*:

- Traditional Treatment (pre-1980’s)
- Conservation/Smart Design (early 1980’s)
- Low Impact Development (LID) (late 1990’s)
- Green Infrastructure (GI) (early 2000’s)
- Benefits
- Maintenance
Stormwater Design Philosophy

- End of Pipe treatment – ‘NURP’ ponds
- Conservation Design/Smart Design
- Low Impact Development (LID)
- Green Infrastructure (GI)
1. Rainfall

2. Surface runoff

3. Underground Pipes and Storm Drains (Catch Basins)

End of Pipe Treatment

© Andy Erickson
Stormwater Infrastructure
Underground pipes take runoff away from the area...
...to a place where it is captured and stored.
‘NURP’ ponds

- effective for providing runoff detention storage (Rate/volume)
- treatment is settling of particulates and their associated pollutants as stormwater runoff resides in the pond (quality)
Development significantly impacts how and where water flows.
Get this...

...to function like this.
Conservation Design

1. Minimize impervious cover
2. Disconnect impervious cover
3. Protect natural areas
Protect natural areas, and let them work naturally...
Planning-Implementation

- Inventory
  - Water bodies & quality
  - Shoreline type
  - Floodplains
  - Plant & wildlife communities
  - Soils
  - Topography
  - Natural areas
  - Other community resources

- Assessment
- Comp Plan
- CD Implementation
Planning-Implementation

- Evaluate and prioritize resources for protection
- Considerations:
  - Regional plans & priorities
  - Watershed plans & priorities
  - Opportunities and threats to protection
  - Community values
- GIS based (simple to complex)
Planning-Implementation

- Develop goals & policies
- Zoning (conservation design)
- Other regulations (stormwater)
- Other tools
  - Land & easement acquisition
  - Park & open space development

Inventory → Assessment → Comp Plan → CD Implementation
Planning-Implementation

- Inventory
- Assessment
- Comp Plan
- CD Implementation

- Conservation Design Ordinance
  - Identify protection priorities (be specific !!!!)
  - Engage community
  - Determine CD ordinance approach
  - Draft standards
Low Impact Development

“Low Impact Development (LID) is an approach to stormwater management that mimics a site's natural hydrology, and is a versatile approach that can be applied to new development, urban retrofits, and redevelopment.” - EPA
History of LID

- Prince George's County, Maryland, in the mid-1980s.

- LID was pioneered to help Prince George’s County address the growing economic and environmental limitations of conventional stormwater management practices.

- LID allows for greater development potential with less environmental impacts through the use of smarter designs and advanced technologies that achieve a better balance between conservation, growth, ecosystem protection, and public health / quality of life.
Low-Impact Development Design Strategies
An Integrated Design Approach

Prepared by:
Prince George's County, Maryland
Department of Environmental Resources
Programs and Planning Division

June 1999

- Site Planning
- Hydrology
- Distributed IMP Technologies
- Erosion and Sediment Control
- Public Outreach
Reduce impervious surfaces = less rate, quantity, and NPS
Keep runoff on site, and help it soak into the ground (infiltration)...
Treatment Train Approach

Andy Erickson, SAFL
Filter Trenches around wet detention ponds (Prior Lake, MN)

Volume Treated by Trenches (Filter Volume)

Normal Water Surface Elevation

Overflow Grate

Water Level Control Weir

Drain tile

Minnesota Filter

Drain tile
Rainwater Garden Layout
Burnsville Rain Gardens - Monitoring Results
Neighborhood Runoff Post-BMP

Average Percent Runoff
Pre- and Post-Construction

Average Rainfall
- Pre-Construction: 0.88"
- Post-Construction: 0.38"

Pre-Construction (N=25)
- Average Percent Runoff:
  - Treatment Watershed: 27%
  - Control Watershed: 25%

Post-Construction (N=24)
- Average Percent Runoff:
  - Treatment Watershed: 5%
  - Control Watershed: 27%

Legend:
- Treatment Watershed
- Control Watershed
Follow-up Monitoring - 5 years later

~56% reduction in volume of runoff
What **Color** is Your Infrastructure?

Using Green Practices to Improve Water Quality and Save Money
Green Infrastructure

Green infrastructure uses *vegetation, soils, and natural processes* to manage water and create healthier urban environments.

- **At the scale of a city or county**, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water.

- **At the scale of a neighborhood or site**, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water.
Green Infrastructure

- native plantings
- rain gardens
- porous pavements
- green roofs
- infiltration planters
- trees and tree boxes
- rainwater harvesting
Green Infrastructure Practices
City of Minnetonka Campus
37th Avenue Greenway - Mpls
37th Avenue Greenway - Mpls
Maplewood Mall
Green Roofs
‘Living Streets’
Green Infrastructure in the Shoreland Area
Green Infrastructure in the Shoreland Area
After: Biolog at Toe, Planted Buffer
Designed & Installed by:
Natural Shore Technologies
LID and Green Infrastructure
"Green infrastructure" is a relatively new and flexible term, and it has been used differently in different contexts. However, for the purposes of EPA's efforts to implement the Green Infrastructure Statement of Intent (PDF), EPA intends the term "green infrastructure" to generally refer to systems and practices that use or mimic natural processes to *infiltrate*, *evapotranspirate* (the return of water to the atmosphere either through evaporation or by plants), or *reuse* stormwater or runoff on the site where it is generated. Green infrastructure can be used at a wide range of landscape scales in place of, or in addition to, more traditional stormwater control elements to support the principles of LID.” – EPA
Dogs can help, too!
Benefits and Incentives

- **Environmental**
  - Improved water quality
  - Improved air quality
  - Improved groundwater recharge
  - Energy savings from reduced air conditioning
  - Reduced greenhouse gas emissions
  - Reduced urban heat stress
  - Reduced sewer overflows

- **Economic**
  - Reduced construction costs with grey infrastructure

- **Social**
  - Improved aesthetics
  - More urban greenways
  - Increased public education
  - Reduced flash flooding
  - Green jobs
  - Increase in economic development
Tools and Resources

- Minnesota Stormwater Manual – MPCA website
- Low Impact Development Center
- US EPA
- Valuation of LID and Green Infrastructure
  - Triple Bottom Line, Ohio
  - ITree Eco [http://www.itreetools.org/eco/](http://www.itreetools.org/eco/)
  - Socio-economics modeling [https://implan.com/](https://implan.com/)
  - Tools to measure success in achieving social goals [http://nextcity.org/topic/civic-tech](http://nextcity.org/topic/civic-tech)
Stormwater BMP’s
Maintenance, Maintenance, Maintenance!
BMPs in the MCWD

- 330 - Infiltration, filtration, bioretention, etc.
- 425 - Wet or dry ponds
- 300 - Sump catch basins
- 45 - Underground storage/proprietary devices
- 30 - Green roofs, porous pavers/ashphalt
Performance longevity of stormwater BMP’s is dependent on maintenance actions.

NO Maintenance = NO Operation

Figure 3.4: Levels of Maintenance for Stormwater Treatment Practices.
Issues to Consider

- Costs – can be considerable and can change
- Lack of awareness – what to do and when
- Lack of resources
- Who’s responsible?
  - Cities
  - Watersheds
  - Counties
  - Developers
  - Private Landowners
Addressing Maintenance

- Regulatory authority
  - MS4 permits
  - Maintenance agreements
  - Inspection requirements

- Education
  - Training
  - Outreach
Blue Community Makeover™
Connelly – permeable paver driveway
4 Trees
25 Raingardens
14 Permeable Pavements
22 Rain Barrels
3 RainXchanges
34 Households
1,617 Volunteer Hours
1.5 million gallons/yr
3.3 lbs P/yr
$224,224 Clean Water Funds
Channel Road

2008

Existing conditions
– 18.5’ road, no curb
– Residential to south and west
– Interlachen Road to east
– Wilkes Park to north

2009

Road Reconstruction
– 20’ wide road, curb
– + 940 sq ft impervious cover
– Raingarden in Wilkes Park
– 5.08 ac tributary
– C/D soils
– 70% TP removal
– No drain tile
Big bluestem  
Monkey flower  
Golden alexanders  
Blueflag iris  
Joe-pye-weed  
Marsh milkweed  
Fox sedge  
Bottlebrush sedge  
Red-osier dogwood  
Marsh milkweed
Located 225’ from lake
929’ bottom elevation
929.4’ lake water level

2011 - > 930’ March-June